SUBGRADE STABILIZATION BY USING FLY ASHES, CASE STUDEY IN UNIVERSITI MALAYSIA PAHANG (UMP)

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ABSTRACT

This project is to evaluate the different percentages of fly ashes and different water content for the stabilization of silt soil of sub graded from UMP location in Pahang. Initially, the soil-fly ash mixtures have been analyzed. It has also been researched if it is possible to use as soil stabilization or not. For the research, few experiment have been carried out by using experiment sample such as moisture content, particle size analysis, atterberg limit, compaction test, CBR and specific gravity. As the result of the experiment research, it has been observed and determined that soil- fly ash mixture with different percentages fly ash and water content can be used as soil stabilization of highway and the stabilization material when building highway and every land of road and it also been observed and determined that the increased strength of the mixed material.

ABSTRAK

Projek ini adalah untuk menilai kestabilan hasil daripada peratusan campuran yang berbeza daripada abu terbang dan kadar air dengan kestabilan tanah lumpur yang di nilai dari lokasi UMP di Pahang. Awalnya, campuran tanah dengan abu terbang telah di analisa. Ini juga telah diteliti kegunaan abu terbang dalam kestabilan tanah sesuai atau tidak sesuai. Untuk kajian ini, beberapa percubaan telah dilakukan dengan menggunakan sampel percubaan seperti ujikaji kelembapan sampel, analisis saiz zarah, Atterberg limit, ujikaji pemadatan sampel, CBR dan *specific gravity*. Sebagai hasil kajian, ujikaji ini telah diamati dan ditentukan bahawa campuran tanah dengan abu terbang dalam peratusan yang berbeza untuk abu terbang dan kadar air boleh digunakan sebagai kestabilan tanah dari jalan raya dan bahan kestabilan ketika membina jalan raya dan setiap jalan dan juga telah diamati dan ditentukan bahawa peningkatan kekuatan bahan campuran.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Soil stabilization is the alteration of soil properties to improve the engineering performance of soils. The properties most often altered are density, water content, plasticity and strength. Modification of soil properties is the temporary enhancement of sub grade stability to expedite construction.

Fly ash has been used successfully in many projects to improve the strength characteristics of soils. Fly ash can be used to stabilize bases or subgrades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. Typical stabilized soil depths are 15 to 46 centimeters (6 to 18 inches). The primary reason fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils.

Delay time is the elapsed time measured between when the fly ash first comes into contact with water and final compaction of the soil, fly ash and water mixture. Compressive strength is highly dependent upon delay time. Both densities and strength are reduced with increasing delay to final compaction. Delay time is critical due to the rapid nature of the tricalcium aluminate (C3A) reaction that occurs when fly ash is mixed with water. Densities and strengths are reduced because a portion of the compactive energy must be used to overcome the bonding of the soil particle by cementation and because a portion of the cementation potential is lost. Maximum strength in soil-fly ash mixtures is attained at no delay. Typically, a one-hour compaction delay is specified for construction purposes.

The water content of the fly ash stabilized soil mixture affects the strength. The maximum strength realized in soil-fly ash mixtures generally occurs at moisture contents below optimum moisture content for density. For silt and clay soils the optimum moisture content for strength is generally four to eight percent below optimum for maximum density. For granular soils the optimum moisture content for maximum strength is generally one to three percent below optimum moisture for density. Therefore, it is crucial that moisture content be controlled during construction. Moisture content is usually measured using a nuclear density measurement device.

Typical fly ash addition rates are 8 percent to 16 percent based on dry weight of soil. The addition rate depends on the nature of the soil, the characteristics of the fly ash and the strength desired. The addition rate must be determined by laboratory mix design testing. In general the higher the addition rate the higher the realized compressive strength. Fly ashes for state department of transportation projects are usually specified to meet AASHTO M 295 (ASTM C 618), even though the requirements of this specification are not necessary for this application and may increase the ash supply costs. Increasingly non-AASHTO M 295 compliant materials are being successfully used. It should be noted that virtually any fly ash that has at least some self-cementations properties can be engineered to perform in transportation projects.

1.2 PROBLEM STATEMENT

One location in Universiti Malaysia Pahang (UMP) has been identified as one of the roads damaged by the sub-grade. Therefore, to restore the road is improved by adding fly ash with the soil as the stabilization.

Fly ash is produced by coal-fired electric and steam generating plants. Fly ash is the finely divided residue that results from the combustion of pulverized coal. Fly ash utilization has significant environmental benefits including increasing the life of stabilization of road by improving the soil stabilization. Using fly ash in soil stabilization can reduction in amount of coal combustion products that must be disposed in landfill and conservation of other natural resources and materials.

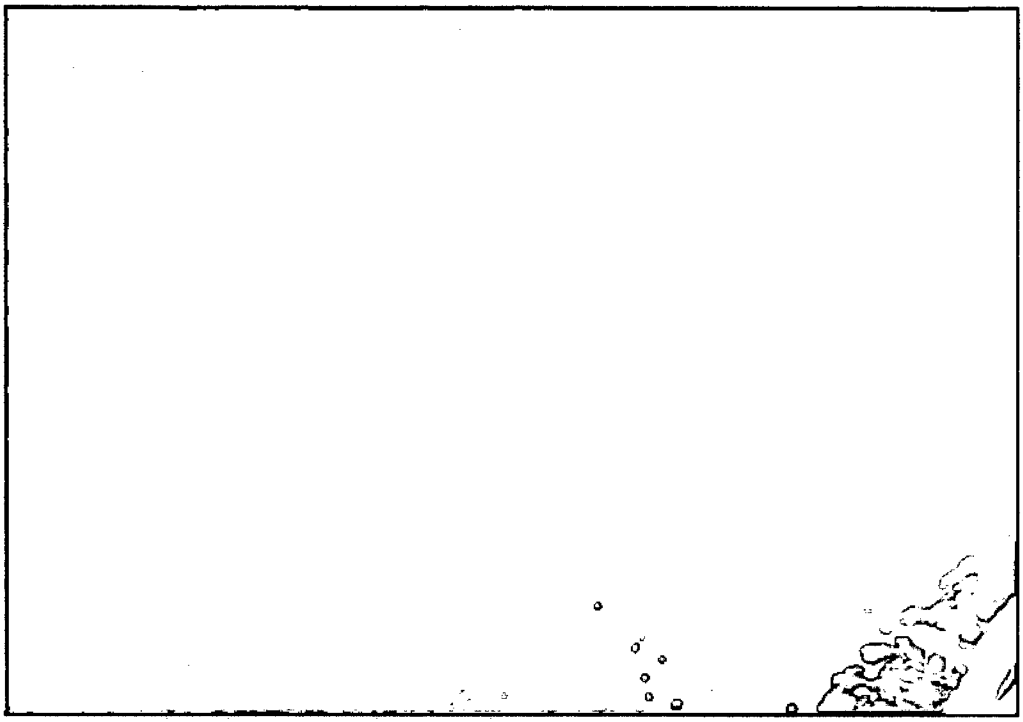

Figure 1.1: One of the roads damaged by the sub-grade at UMP

1.3 OBJECTIVES OF STUDY

The objectives of this study are;

i. To improve the workability and effectiveness of soil stabilization by using fly ash.
ii. To determine the optimum moisture content of fly ash that give maximum CBR value for 4% and 8% soil-fly ash mixture.
iii. To understand the problems facing as dealing with the fly ash for soil stabilization.

1.4 SCOPE OF STUDY

The study is focused on the identification of soil-fly ash mixture, classification of soil, and the engineering characteristics of the soil-fly ash mixture.

The sample has been taking at Universiti Malaysia Pahang (UMP) area, and soil testing will be determining the effectiveness of the several of percentage fly ash in soil. From the testing, the analysis of data will be prepared as a result of the experiment.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

People travel for some reason. Although airway, railway, seaway and highway are for traveling, highway is preferred since it is more economic than others, especially for shorter distance. Therefore, the surface course is the top layer and the layer that comes in contact with traffic. The pavement can be lower quality because of movement of traffic. Due to the fact that, this chapter will be more focus on soil and fly ash mixture which are the most economic among others.

2.2 SOIL PROPERTIES

Soil is the particular media, substances having a skeleton of easily separable particles which enclose interconnected and irregularly shaped voids. The void space may be wholly or partly filled with a liquid, generally water containing salt in solution. (Braja, 2006)

The plasticity of soils treated with Class C or other high-calcium fly ash is influenced by the types of clay minerals present in the soil and their adsorbed water. Soils containing more than 10 percent sulfates have been prone to swell excessively in some applications. Also, organic soils are difficult to stabilize using fly ash. (Monden, 1960)

The soil types in turn serve as a basis for making prediction of engineering significance. The soil types in turn serve as a identified by a study of soil characteristics, it follows that, case established, the soil classification is a source of information relative to soil characteristic. From knowledge of characteristic, the engineer is able to estimate soil properties and to determine the suitability of the soil for engineering purposes. (Braja, 2006)

2.3 SOIL STABILIZATION

Pavement design is based on the premise that minimum specified structural quality will be achieved for each layer of material in the pavement system. Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted. (Gray, 1994)

In the selection of a stabilize, the factors that must be considered are the type of soil to be stabilized, the purpose for which the stabilized layer will be used, the type of soil improvement desired, the required strength and durability o the stabilized layer, and the cost and environmental conditions.

Fly ash has been used successfully in many projects to improve the strength characteristics of soils. Fly ash can be used to stabilize bases or subgrades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. Typical stabilized soil depths are 15 to 46 centimeters (6 to 18 inches). The primary reason fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils. (Oberst, 1985)

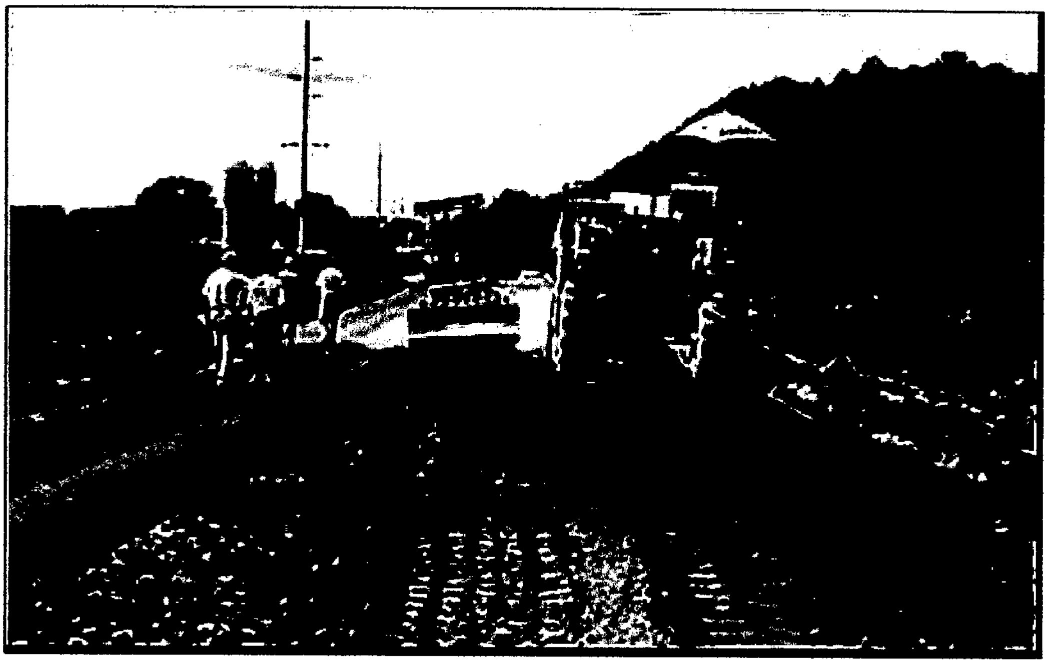

Figure 2.1: Mixing and shaping of fly ash stabilized soil.

Stabilization of coarse-grained soils having little or no tines can often be accomplished by the use of fly ash. Fly ash, also termed coal ash, is a mineral residual from the combustion of pulverized coal. It contains silicon and aluminum compounds that, when mixed with soil. Fly ash in mixed with soil can often be used successfully in stabilizing granular materials since the fly ash provides an agent. Thus fly ash stabilization is often appropriate for base and subbase course materials. (Wong, 1989)

Type Course	Sieve Size	Percent Passing
Base	2 in	100
	¾ in	70-100
	3/8 in	50-80
	No.4	35-70
	No.8	25-55
	No.16	10-45
	No.200	0-15
Subbase	1 ½ in	100
	No.4	45-100
	No. 4	10-50
	No. 200	0-15

Table 2.1: Gradation requirement for fly ash stabilized base and subbase courses (Wong 1989)

2.4 FLY ASH

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. Fly ash is produced by coal-fired electric and steam generating plants. Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately ignites, generating heat and producing a molten mineral residue. Boiler tubes extract heat from the boiler, cooling the flue gas and causing the molten mineral residue to harden and form ash. Coarse ash particles, referred to as bottom ash or slag, fall to the bottom of the combustion chamber, while the lighter fine ash particles, termed fly ash, remain suspended in the flue gas. Prior to exhausting the flue gas, fly ash is removed by particulate emission control devices, such as electrostatic precipitators or filter fabric bag houses. (Acosta, 2002)

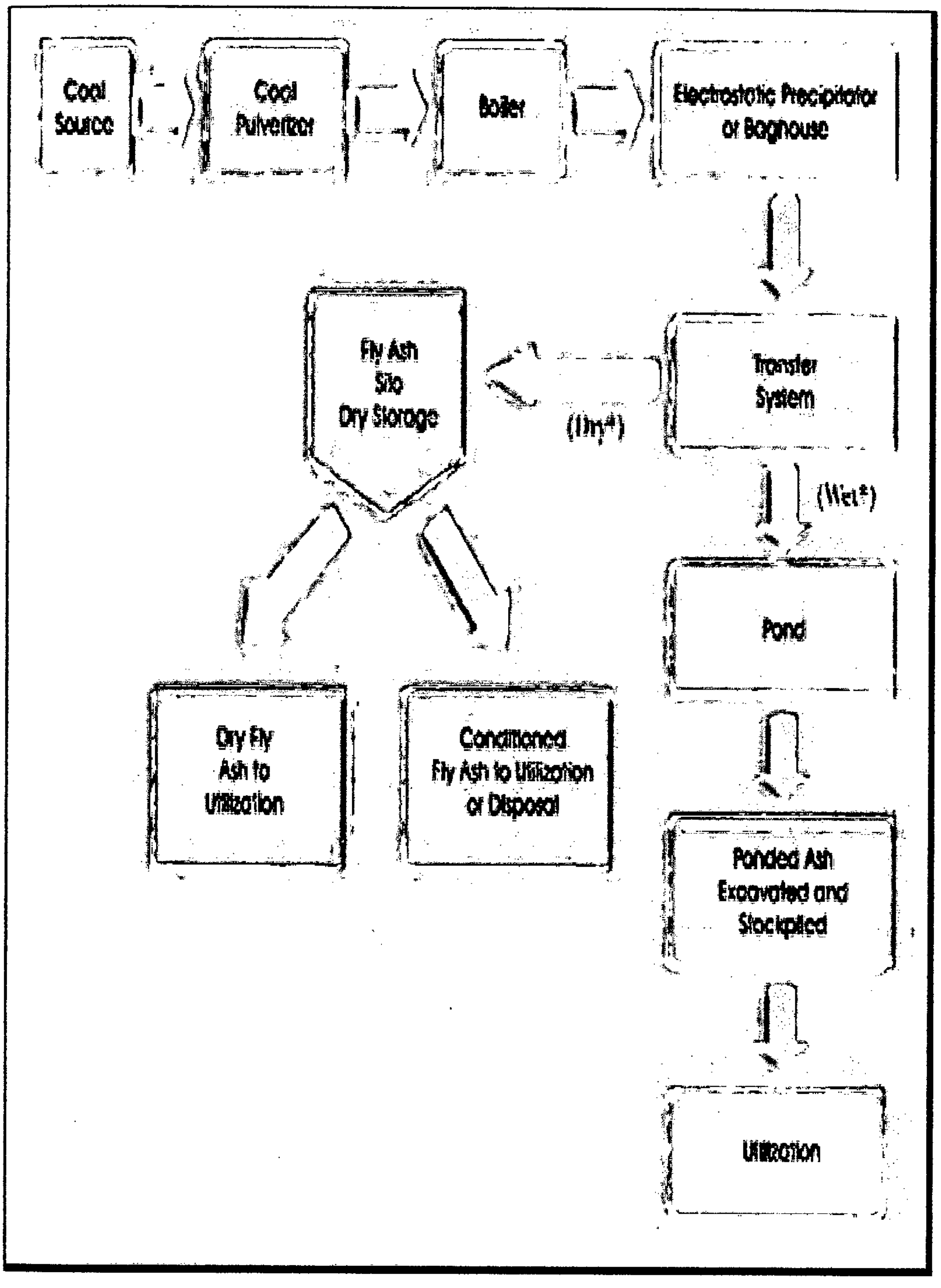

Figure 2.2: Method of fly ash transfer can be dry, wet or both. (Acosta, 2002)

Fly ash is most commonly used as a pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. The unique spherical shape and particle size distribution of fly ash make it a good mineral filler in hot mix asphalt (HMA) applications and improves the fluidity of flow able fill and grout. The consistency and abundance of fly ash in many areas present unique opportunities for use in structural fills and other highway applications. (Meyersel, 1976)

2.4.1 FLY ASH CHARACTERISTICS

Fly ash is typically finer than portland cement and lime. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100 micron (Figure 2). These small glass spheres improve the fluidity and workability of fresh concrete. Fineness is one of the important properties contributing to the pozzolanic reactivity of fly ash.

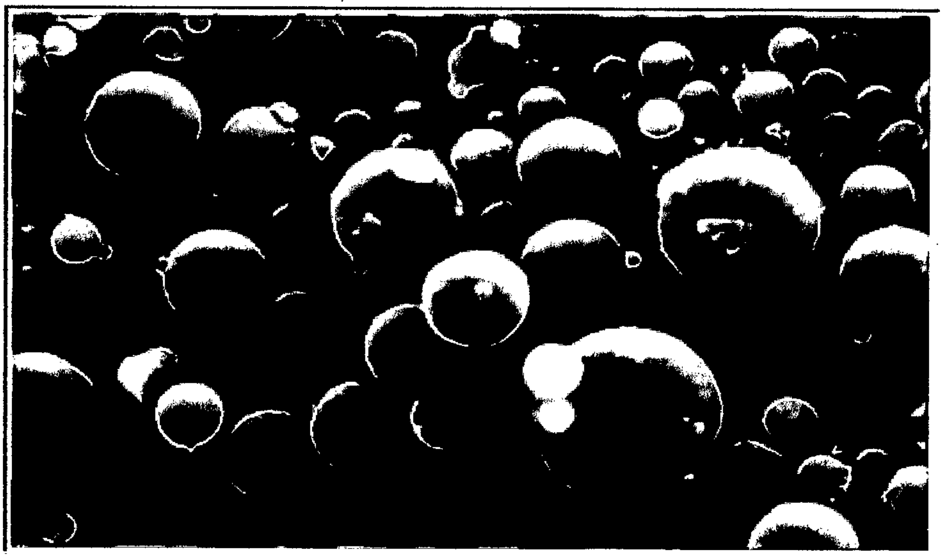

Figure 2.3: Fly ash particles at 2,000x magnification

Fly ash consists primarily of oxides of silicon, aluminum iron and calcium. Magnesium, potassium, sodium, titanium, and sulfur are also present to a lesser degree. When used as a mineral admixture in concrete, fly ash is classified as either Class C or Class F ash based on its chemical composition. American Association of State Highway Transportation Officials (AASHTO) M 295 [American Society for Testing and Materials (ASTM) Specification C 618] defines the chemical composition of Class C and Class F fly ash.

Class C ashes are generally derived from sub-bituminous coals and consist primarily of calcium alumino-sulfate glass, as well as quartz, tricalcium aluminate, and free lime (CaO). Class C ash is also referred to as high calcium fly ash because it typically contains more than 20 percent CaO. Class F ashes are typically derived from bituminous and anthracite coals and consist primarily of an alumino-silicate glass, with quartz, mullite, and magnetite also present. Class F, or low calcium fly ash has less than 10 percent CaO. (Acosta 2002)

Compounds	Fly Ash Class F	Fly Ash Class C
SiO_2	55	40
Al_2O_3	26	17
Fe_2O_3	7	6
CaO (Lime)	9	24
MgO	2	5
SO_3	1	3

Table 2.2: Sample oxide analysis of fly ash. (Acosta 2002)

2.4.2 QUALITY OF FLY ASH

Quality requirements for fly ash vary depending on the intended use. Fly ash quality is affected by fuel characteristics (coal), cofiring of fuels (bituminous and sub-bituminous coals), and various aspects of the combustion and flue gas cleaning/collection processes. The four most relevant characteristics of fly ash for use in concrete are loss on ignition (LOI), fineness, chemical composition and uniformity.

ACT 229R	Controlled low Strength material (CLSM)
ASTM C 311	Sampling and Testing Fly Ash or Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
AASHTO M 295	Fly Ash and raw or Calcined natural Pozzolan for Use as a Mineral
ASTM C 618	Admixture in Portland Cement Concrete
ASTM C 593	Fly Ash and other Pozzolans for Use With Lime
ASTM D 5239	Standard Practice for Characterizing Fly sh for use in Soil Stabilization
ASTM E 1861	Guide for the use Coal Combustion By-Products in Structural Fills

Table 2.3: Guidance documents used for fly ash quality assurance (Bowders, 1990)

LOI is a measurement of unburned carbon (coal) remaining in the ash and is a critical characteristic of fly ash, especially for concrete applications. High carbon levels, the type of carbon (i.e., activated), the interaction of soluble ions in fly ash, and the variability of carbon content can result in significant air entrainment problems in fresh concrete and can adversely affect the durability of concrete. AASHTO and ASTM specify limits for LOI.

However, some state transportation departments will specify a lower level for LOI. Carbon can also be removed from fly ash.(Turner, 1997; Senol, 2003)

Fineness of fly ash is most closely related to the operating condition of the coal crushers and the grind ability of the coal itself. A coarser gradation can result in a less reactive ash and could contain higher carbon contents. Limits on fineness are addressed by ASTM and state transportation department specifications. Fly ash can be processed by screening or air classification to improve its fineness and reactivity. (Bowders, 1990)

2.4.3 FLY ASH IN SOIL IMPROVEMENT

Soil stabilization is the alteration of soil properties to improve the engineering performance of soils. The properties most often altered are density, water content, plasticity and strength. Modification of soil properties is the temporary enhancement of subgrade stability to expedite construction. Class C fly ash and Class F-lime product blends can be used in numerous geotechnical applications common with highway construction to enhance strength properties, stabilize embankments, control shrink swell properties of expansive soils, drying agent to reduce soil moisture contents to permit compaction.

Class C fly ash can be used as a stand-alone material because of its self-cementations properties. Class F fly ash can be used in soil stabilization applications with the addition of a cementations agent (lime, lime kiln dust, CKD, and cement). The self-cementations behavior of fly ashes is determined by ASTM D 5239. This test provides a standard method for determining the compressive strength of cubes made with fly ash and water (water/fly ash